

Chapter 6: Heat ExchangerHot fluidcold fluid

$$T_{h,i} =$$

$$t_{c,i} =$$

$$T_{h,o} =$$

$$t_{c,o} =$$

$$\dot{m}_h =$$

$$\dot{m}_c =$$

$$C_{p,h} =$$

$$C_{p,c} =$$

$$Q_h = \dot{m}_h C_{p,h} [T_{h,i} - T_{h,o}]$$

$$Q_c = \dot{m}_c C_{p,c} [t_{c,o} - t_{c,i}]$$

$$Q = Q_h = Q_c$$

$$Q = UA(LMTD)$$

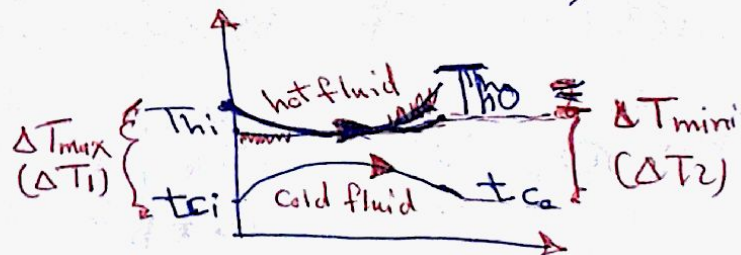
$\square$  LMTD  $\rightarrow$  Difference  
 Logarithmic  $\rightarrow$  Mean  $\rightarrow$  Temperature

a) Parallel flow

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

$$\Delta T_1 = T_{h,i} - t_{c,i}$$

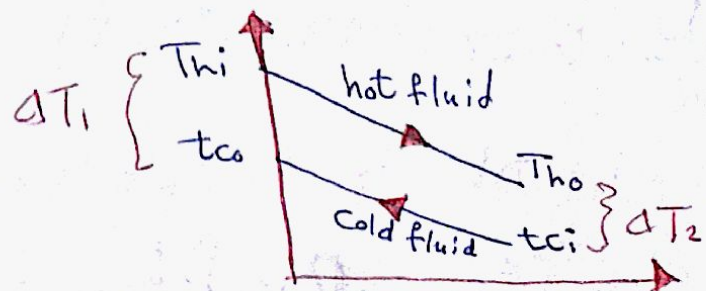
$$\Delta T_2 = T_{h,o} - t_{c,o}$$

b) Counter flow

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln \left( \frac{\Delta T_1}{\Delta T_2} \right)}$$

$$\Delta T_1 = T_{h,i} - t_{c,o}$$

$$\Delta T_2 = T_{h,o} - t_{c,i}$$





[2]  $U = ??$

a) overall heat transfer coefficient is given  $[W/m^2K]$

b)  $[h]$  is given (convection heat transfer coefficient)  $[W/m^2K]$

$$\therefore UA = \frac{1}{\sum R_{th}} \Rightarrow UA = \frac{1}{\frac{1}{hA}} \Rightarrow UA = hA$$

$$\therefore \boxed{U = h}$$

c)  $[2h] \Rightarrow (h_c, h_h)$

$$\therefore U = \left[ \frac{1}{\frac{1}{h_c A} + \frac{1}{h_h A}} \right]$$

(d)  $Nu = \left[ \frac{hL_c}{k} \right] (Pe)^{\frac{1}{4}}$

$$Nu = \frac{hL_c}{k} \Rightarrow h = \frac{k}{L_c}$$

$$\therefore \boxed{U = h}$$

from Nusselt No. eq.  $\Rightarrow$  get  $[h]$

[3] Area of cylinder (tube)

مساحة الجانبي للأنبوب

$$\boxed{A = \pi D_o L N_{total}}$$

$N_{total}$  = total No of tubes

$N_{total} = \text{no of passes} \times n \rightarrow (\text{no of tubes})$   
 عدد الممرات  $\times$  عدد الأنابيب

[4]

$$\dot{m} = \rho V \frac{\pi}{4} D_i^2 (n) \rightarrow \text{no of tubes}$$

Single  $\rightarrow$  فرضه بواحد (no of passes)  $\times$  عدد الأنابيب  $\times$  سرعة الجريان

$D_i \rightarrow (m)$

$D_o \rightarrow [A]$



# 1-sheet 6

Hot Fluid [oil]

cold fluid [water]

$$T_{h,i} = 150^\circ\text{C}$$

$$T_{h,o} = ?$$

$$\dot{m}_h = \frac{3500}{3600} \text{ kg/s}$$

$$C_{ph} = 1000 \text{ J/kg}\cdot\text{K}$$

$$D_i = 0.1006 \text{ m}$$

$$t_{c,i} = 40^\circ\text{C}$$

$$t_{c,o} = 85^\circ\text{C}$$

$$\dot{m}_c = \frac{1000}{3600} \text{ kg/s}$$

$$C_{pc} = 4178 \text{ J/kg}\cdot\text{K}$$

$C_{pw}$  "slightly less"

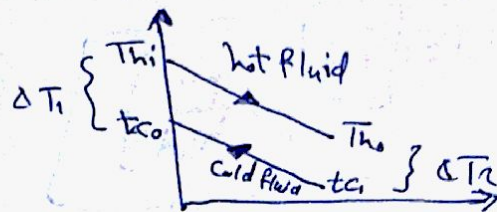
$$V_w = 2 \text{ m/s}$$

Counter

no of Passes = 1

$$U = 1000 \text{ W/m}^2\cdot\text{K}$$

Req:  $N_{total} = ?$ ,  $n = ?$ ,  $L = ?$



\* How to solve?

$$\dot{m}_w = \rho_w V_w \frac{\pi}{4} D_i^2 n$$

$$n = \square \quad (\text{مع تقريب لأقرب})$$

$$q = UA [LMTD]$$

$$q = U \pi D_i L \underbrace{N_{total}}_{(\text{no of Pass} \times n)} [LMTD]$$

$$\therefore q_{rh} = q_{rc} = q$$

$$\therefore \dot{m}_h C_{ph} [T_{h,i} - T_{h,o}] = \dot{m}_c C_{pc} [t_{c,o} - t_{c,i}]$$

$$\Rightarrow T_{h,o} = \square^\circ\text{C}$$

$$\therefore LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln \left( \frac{\Delta T_1}{\Delta T_2} \right)} = \square$$

$$\Delta T_1 = T_{h,i} - t_{c,o}$$

$$\Delta T_2 = T_{h,o} - t_{c,i}$$

$$q = U \pi D_i L N_{total} [LMTD]$$

$$\Rightarrow L = \square \text{ m}$$



# (4-sheet 6) - very Important

Hot fluid [oil]

$$T_{oi} = 90^\circ\text{C}$$

$$T_{oo} = 50^\circ\text{C}$$

$$\dot{m}_o = 0.1 \text{ kg/s}$$

$$h_o = 400 \text{ W/m}^2\text{K}$$

$$C_{p_o} = 2131 \text{ J/kgK}$$

Cold fluid [water]

$$t_{wi} = 30^\circ\text{C}$$

$$t_{wo} = ??$$

$$\dot{m}_w = 0.12 \text{ kg/s}$$

$$C_{p_w} = 4178 \text{ J/kgK}$$

$$h_w = h_c = 3000 \text{ W/m}^2\text{K}$$

Given

Gunter

$$n = 10$$

$$D = 0.025 \text{ m}$$

no of Passes = 1  
(single)

Reqd

1)  $Q_h = ?$

2)  $t_{wo} = ?$

3)  $U = ?$

4)  $\text{LMTD} = ?$

5)  $L = ?$

Solution:

$$* \text{1) } Q_h = Q_c = \dot{m} c_p [T_{hi} - T_{ho}]$$

$$* \text{2) } Q_h = Q_c$$

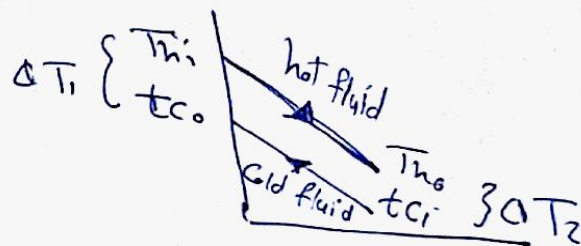
$$Q_h = \dot{m} c_p [t_{co} - t_{ci}]$$

$$* \text{3) } UA = \frac{1}{\sum R_{th}} = \frac{1}{\left[ \frac{1}{h_w A} + \frac{1}{h_o A} \right]}$$

$$* \text{4) } \text{LMTD} = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

$$\Delta T_1 = T_{hi} - t_{co}$$

$$\Delta T_2 = T_{ho} - t_{ci}$$



$$* \text{5) } Q = U A D [L] N_{total} [\text{LMTD}]$$

$$N_{total} = \text{no of Passes} * n = 10 * 1 = 10$$

$$\Rightarrow L = \square \text{ m}$$